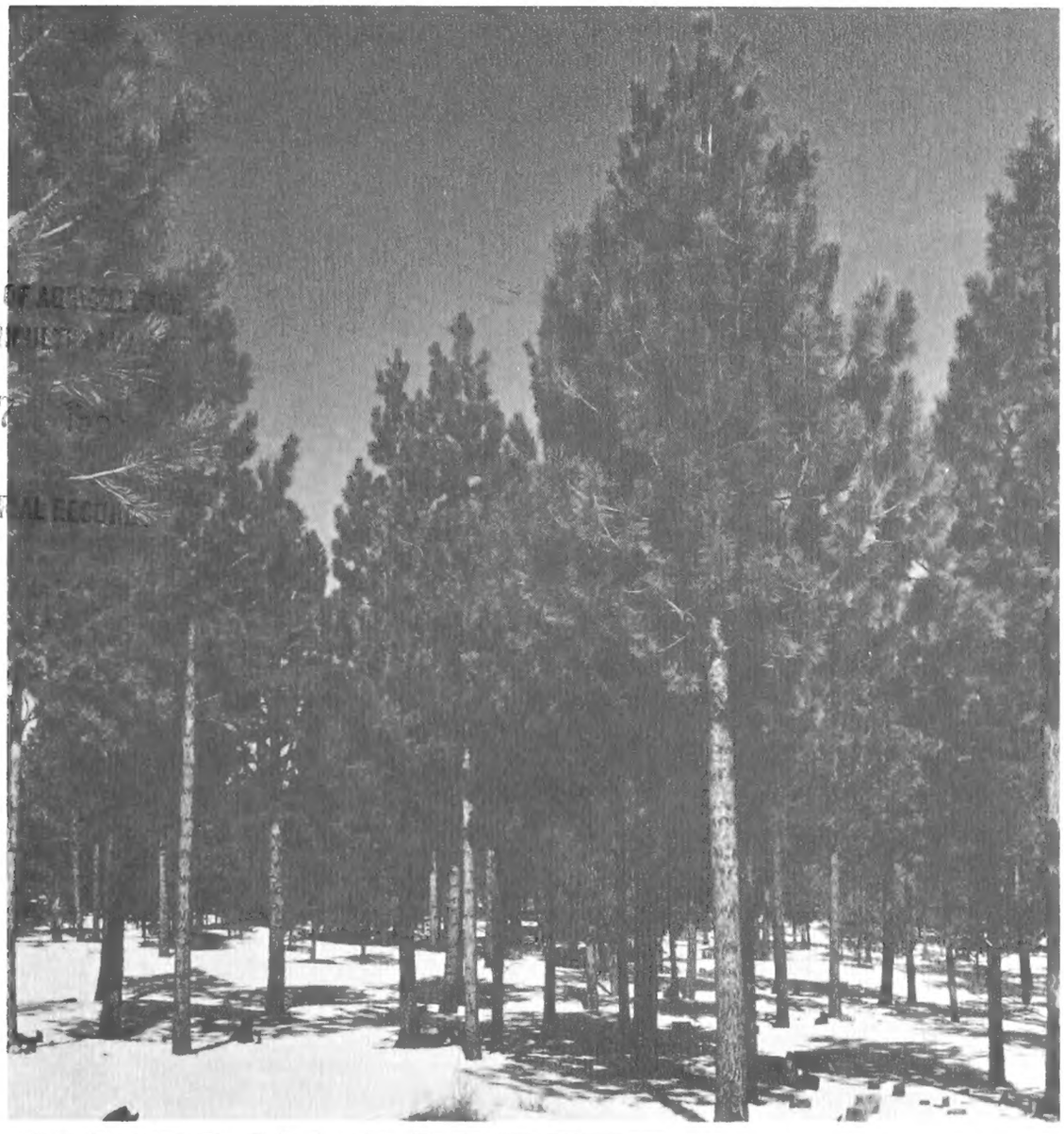
PRUNING OF PONDEROSA PINE..

EFFECT ON GROWTH



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CONTENTS

In Pacific Northwest ponderosa pine forests, investments in thinning have been favored over those for pruning. Now, there is evidence that adequately released crop trees are growing fast enough so that pruning for quality improvement may be a profitable investment. Also, with availability of a new self-propelled tree pruner (6) that can limb higher, faster, and possibly cheaper than conventional methods, interest has been stimulated in the profitable production of clear wood. However, with higher pruning in prospect, the amount of live crown removed becomes of concern. How much living crown can be removed without adversely affecting growth?

THE STUDY

Four 2-acre plots were established in 1941 in a 55-year-old stand of ponderosa pine on the Pringle Falls Experimental Forest in central Oregon where site index was 78 feet at 100 years (7). On each plot, 96 crop trees were selected and subdivided into four subplots of 24 trees of which six trees at random were assigned to each of four pruning treatments. Treatments consisted of (a) unpruned,[1/] (b) pruning of one-fourth, (c) one-half, and (d) three-fourths of the length of live crown.[2/] The amount of pruning necessary for each tree was determined by measuring live crown length to the nearest foot with a topographic abney level and tape and calculating the necessary pruning height to remove the appropriate amount of crown length. Dead branches were removed in all treatments. Trees were climbed to the desired length of removal and then pruned downward. Branches were left where they fell.

Trees chosen ranged from 6 to 18 inches in diameter, from 25 to 76 feet in height, and were representative

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[1/] Dead branches only were removed from trees referred to in the text as unpruned.

[2/] Live crown length, referred to in the text, is the distance along the main stem of the tree from the lowest living branch to the top of the tree.

of dominants or codominants. Averages for trees directly after study establishment were as follows:

Proportion of live crown removed	Diameter breast high (Inches)	Total tree height (Feet)	Height pruned (Feet)
0	10.10	46.5	13.3
1/4	10.42	48.2	22.6
1/2	10.60	47.5	30.6
3/4	10.59	47.0	38.5

Since live crown length and height to bottom branches of live crown before pruning varied markedly, there obviously was variation in crown length and pruned height between trees that received the same pruning treatment. Therefore, pruning one-fourth of the length of live crown from different trees could result in different volume of crown removed depending on original crown length.

Pruning dead limbs only resulted in clear bole lengths (table 1) ranging from 4 feet to 31 feet. Removal of lower one-fourth of the crown length gave clear bole lengths ranging from 12 to 37 feet; one-half, 17 to 47 feet; and three-fourths, 21 to 58 feet.

Height to live crown, total height, and diameter measurements and dominance classification were made at the time of study establishment and 5, 10, and 16 years later. Effects of pruning on growth during the first 5-year period were reported by Mowat (8) and during the 10 years subsequent to pruning by Dahms (1).

RESULTS

Diameter Growth

Pruning of live crown significantly

Table 1.--Number of ponderosa pine trees pruned in each clear bole length class, by proportion of crown length removed, 1941

Proportion of live-crown length removed	Clear bole length classes (feet)												Total
	4	8	12	16	20	24	28	32	36	40	44	48+	
	Number												
0	5	21	45	19	5	--	--	1	--	--	--	--	96
1/4	--	--	10	13	34	20	12	6	1	--	--	--	96
1/2	--	--	--	3	11	16	20	21	19	2	3	1	96
3/4	--	--	--	--	4	2	14	14	19	16	13	14	96

reduced subsequent diameter growth. Treatment averages show that the greater the proportion of crown length removed the less trees grew in diameter (fig. 1). During the first 5 years after pruning, trees with no live crown removed grew at the rate of 2.4 inches per decade (table 2). Removing one-fourth the live-crown length reduced this rate only about 6 percent; removing one-half and three-fourths reduced it by 25 and 63 percent, respectively.

As time passed and crowns increased in length (fig. 2), diameter growth rates tended to recover. For example, trees with only one-fourth of their live-crown length removed grew at the same rate as unpruned trees during the second (5 years) and third (6 years) periods. Even the most severely pruned trees showed substantial recovery by advancing from growth rates of only 37 percent of unpruned trees in the first period to 82 percent of unpruned trees during the third period.

There was a significant trend for larger trees to grow faster than smaller trees, except where three-fourths of the live-crown length was removed (fig. 3). For example, an average 8-inch tree with half its crown removed grew 2.4 inches in 16 years, but a 16-inch tree with the same treatment grew 3.3 inches. Increments on trees most heavily pruned were quite variable and failed to show any consistent relation to diameter at the time of pruning. By removal of the lower one-half of the crown length, diameter growth was reduced about 14 percent in 16 years throughout the range of tree diameters tested. In contrast, removal of lower one-fourth of the crown length only reduced diameter growth about 2.5 percent during the 16-year period.

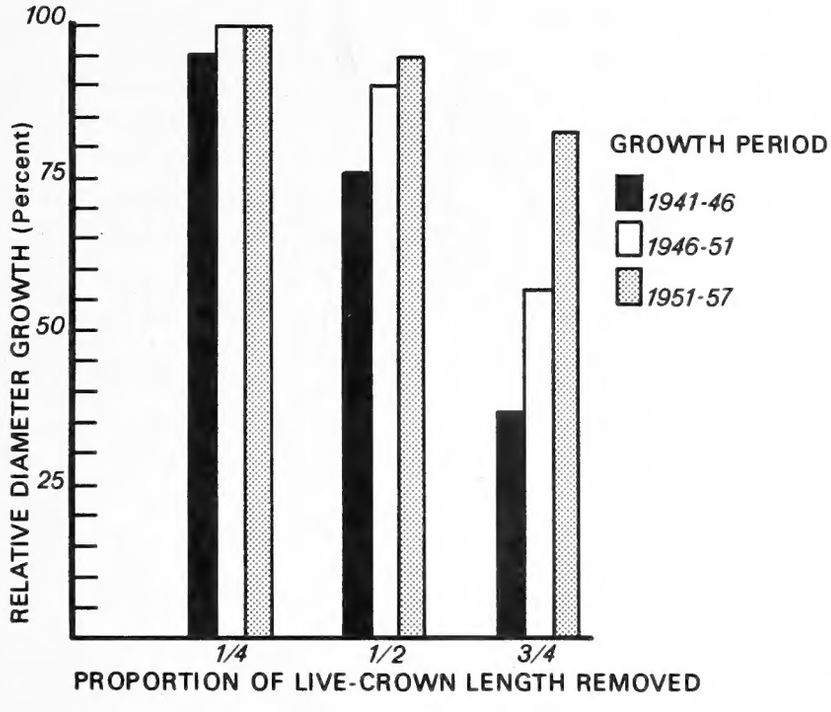

Figure 1.--Diameter growth of trees with live-crown length removed relative to those with only dead limbs removed.

Table 2.--Average annual diameter increment after pruning of ponderosa pine trees, by pruning treatment and growth periods

Proportion of live-crown length removed	1941-46	1946-51	1951-57	1941-57
	Inches			
0	0.239	0.179	0.173	0.195
1/4	.225	.177	.171	.190
1/2	.180	.159	.163	.167
3/4	.088	.102	.142	.112

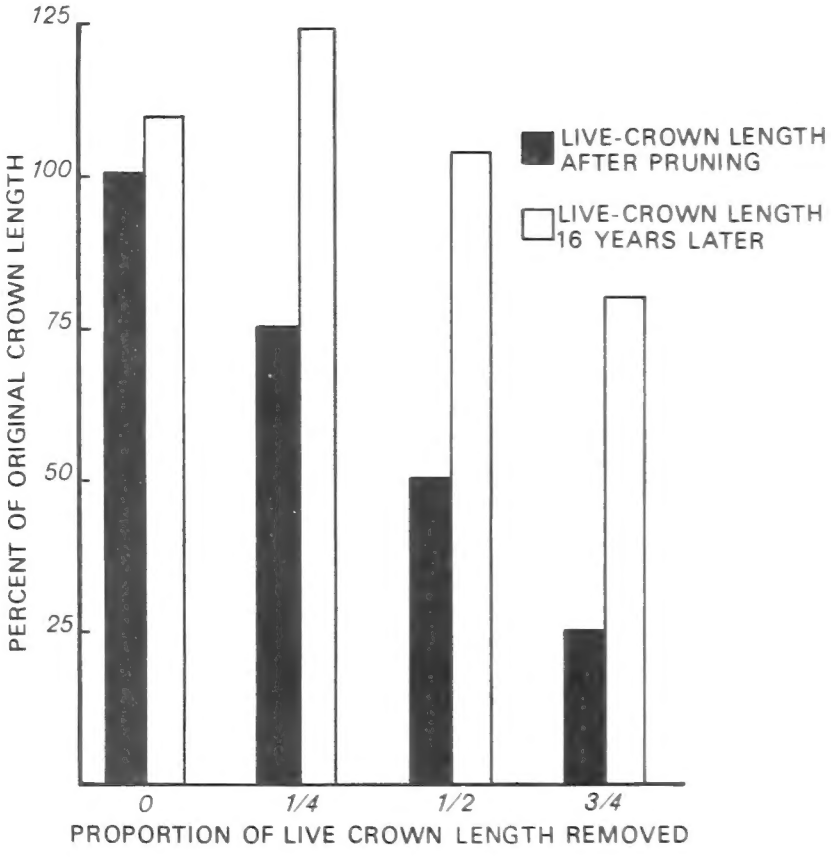

Figure 2.--Live-crown length directly after pruning and 16 years later.

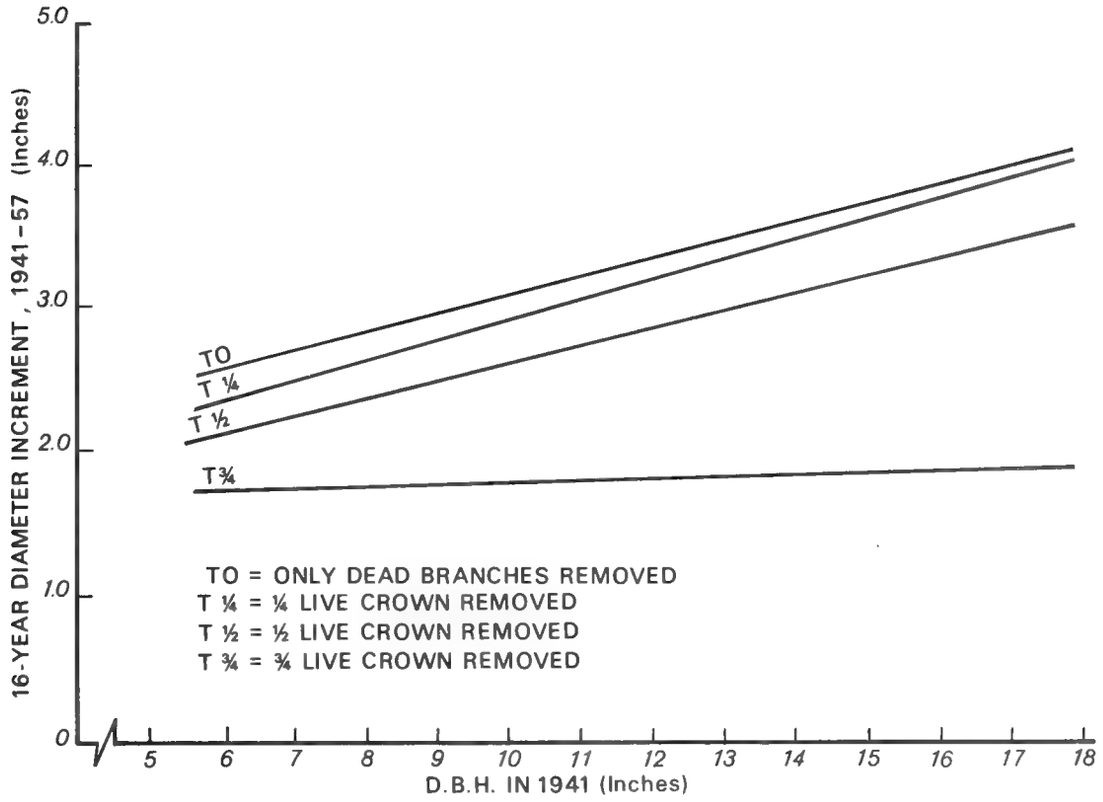

Figure 3.--Relation of 16-year diameter growth to diameter in 1941.

Initial crown length, as well as the proportion removed, affected diameter growth. Among trees within each treatment, diameter growth during the 16 years was significantly correlated with length of live crown before pruning (fig. 4). Thus, trees having a large portion of their total height in crown were less affected by pruning than trees with only a small portion of their height in live crown. Also, there is some evidence shown in the response surface in figure 4 to indicate the removal of lower, shaded branches on large-crowned trees will increase increment.

Height Growth

Height growth was reduced in proportion to severity of treatment, although differences were not great (table 3). During the 16 years, trees that had no live crown removed grew 1.24 feet per year compared with 1.12 feet for the most severly pruned trees. Therefore, the total height of pruned trees differed little from untreated trees in the stand. To illustrate, the average height difference between none and three-fourths crown-length removal amounted to only 2 feet during the 16 years.

Despite these small effects of treatment on height growth, loss of dominance was evident. The percent of trees losing at least one step in dominance during the 16 years follows:

Proportion of live-crown length removed:	Trees with lowered dominance (Percent)
None	10
One-fourth	19
One-half	19
Three-fourths	29

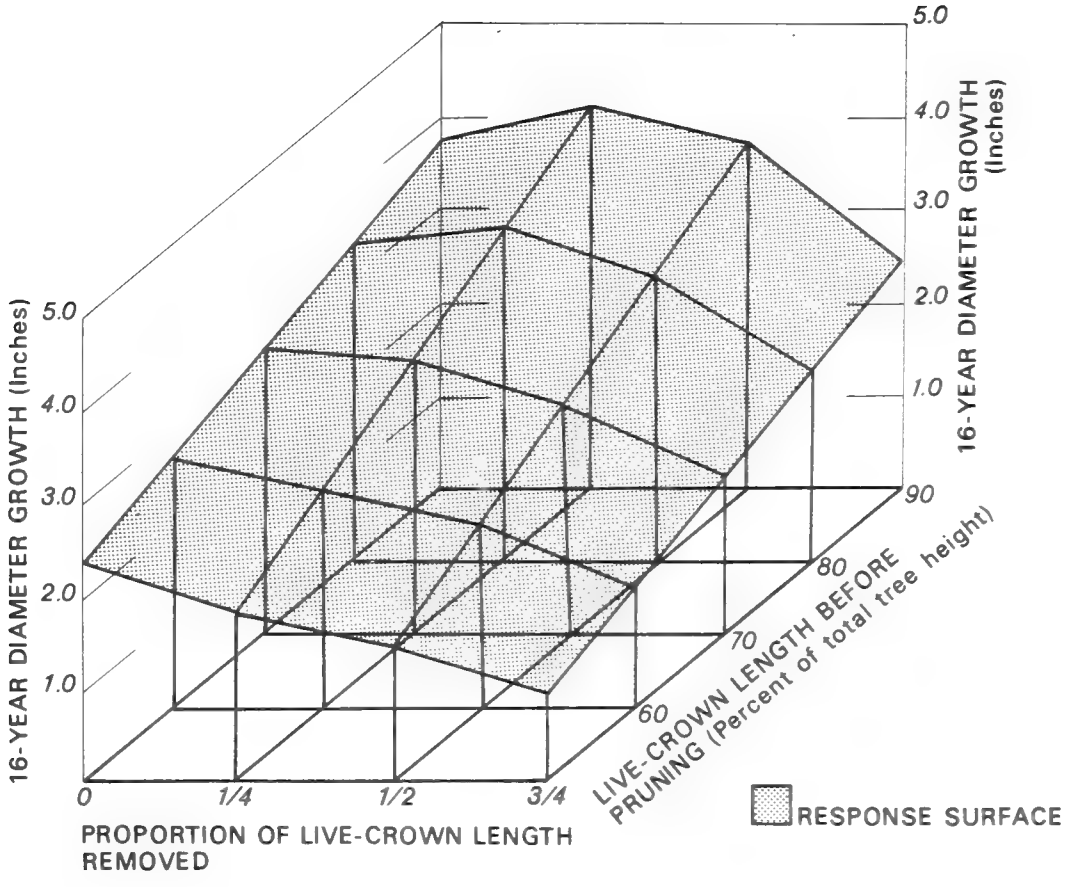

Figure 4.--Diameter growth when various lengths of ponderosa pine crowns are removed.

Table 3.--Average annual height growth after pruning of ponderosa pine trees by pruning treatment and growth periods

Proportion of live-crown length removed	1941-46[1/]		1946-51[1/]		1951-57		1941-57	
	Feet	Percent[2/]	Feet	Percent	Feet	Percent	Feet	Percent
0	1.172	100	1.336	100	1.228	100	1.244	100
1/4	1.101	94	1.348	101	1.245	101	1.233	99
1/2	1.101	94	1.221	91	1.217	99	1.182	95
3/4	1.061	91	1.205	90	1.097	89	1.119	90

[1/] Averages differ slightly from those published by Dahms (1) because trees whose tops were damaged during the last period were dropped from height analyses.

[2/] Percent is of height growth for unpruned trees.

A few trees in all treatments gained in dominance, but most trees lost.

Mortality

Pruning intensity had little effec on mortality. Even trees that had only a few green branches left after pruning remained vigorous. Although half the trees were deliberately pruned at the peak of insect activity, just one died during the first 5 years. Only three trees died during the entire 16 years of observation--one with only dead limbs removed and two with three-fourths of their lower live-crown length removed.

RECOMMENDATIONS AND DISCUSSION

On the basis of 10 years' data, Dahms (1) concluded that "...not more than one-third of the length of the live crown should be removed and that the crown in no event be reduced to less than one-third of the total height of the tree." After 16 years, this same generalization is sound but, with additional data available, separate recommendations can now be made for pruning trees having different initial lengths of live crown.

Existing live-crown length has an important bearing on the percent of crown length that should be pruned from a tree. Full-crowned trees can tolerate more pruning than short-crowned trees. There is, therefore, a variable limit to the number of live branches that can be removed without reducing diameter growth an unacceptable amount.

Obviously, the tolerable amount of growth reduction must be selected by the forest manager after due consideration of management objectives. Table 4 presents growth reductions that can be expected with different lengths of live-crown removal. For example, a tree with 60 percent of its total height in crown could have 20 percent of its lower crown length removed and suffer only 11-percent reduction in diameter growth over a 16-year period. In contrast, a tree with 80 percent of its height in crown could have 30 percent of its lower crown length removed and still maintain its initial diameter-growth rate. If the forester can tolerate very little loss in diameter growth, he should use crown removal and total crown combinations, represented by low percent diameter-growth reductions in the body of table 4.

Removal of 25 percent of the lower live-crown length on full-crowned trees appears to increase subsequent diameter growth (fig. 4). Others have observed this trend in either or both diameter and height growth for pruned Douglas-fir (9), western white pine (5), and ponderosa pine in California (10, p. 3).

One might speculate whether crown recovery (fig. 2) would be the same in a thinned stand of widely spaced trees. Lower branches on an unpruned tree probably would not die as rapidly in a thinned stand as in an unthinned stand. Therefore, in a thinned stand it is unlikely that live crown on trees pruned one-fourth and one-half their lower crown length would equal the crown length for unpruned trees within 16 years.

Data in table 4 and figure 4 indicate that 50 percent of the lower crown

Table 4.--Estimated reductions in diameter growth of ponderosa pine trees caused by removing different proportions of live crown, 16 years after pruning

Portion of total tree height in live crown (percent)	Percent of crown removal								
	10	20	25	30	40	50	60	70	75
	Percent[1/]								
50	10	21	27	28	32	37	46	54	59
60	6	11	13	16	22	25	38	49	50
70	1	2	3	7	14	16	30	40	44
80	0	0	0	0	5	8	23	33	39
90	0	0	0	0	0	1	14	28	34

[1/] Estimated by graphic interpolation of figure 4.

length can be removed on full-crowned (80 to 90 percent of height) trees without causing much reduction in diameter growth. Somewhat the same conclusion was drawn by Hallin (3), and later confirmed by Gordon (2), on a similar study in California, where they recommended removal of up to one-half of the green crown on open-grown trees if four-tenths of the total height remained in green crown. They found that trees with 50 percent of the live crown removed suffered shock initially, but after 5 years "...their growth almost paralleled that for unpruned trees," which grew 3 inches in diameter per decade. Removal of the lower one-fourth of the crown length had no effect on diameter growth, but removal of three-fourths of the crown length reduced growth drastically and 52 percent of trees pruned that much died from insect attack.

Heidman (4), working in the Southwest, found that 40 percent of the live crown can be removed without significantly affecting diameter growth if at least 31 percent of total tree height is left in live crown. He also found crown length to be an important factor in specifying treatment. He suggested that the Southwestern study would have been more meaningful if trees had been pruned to leave specified percentages of tree height in live crown.

Since results from this study and several other ponderosa pine pruning studies essentially agree, the recommendations presented here should be used to sharpen up or modify existing ponderosa pine pruning practices.

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Barrett, James W.
1968. Pruning of ponderosa pine--effect on growth. U.S.D.A. Forest Serv. Res. Pap. PNW-68, 9 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oregon.

The ratio of existing crown length to total height has an important bearing on the proportion of crown length that should be pruned from ponderosa pine. Therefore, there is a variable limit to proportion of crown length that can be removed and still maintain acceptable growth rates. A table is presented that shows diameter growth reduction that can be expected from removing different proportions of live crown length.

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